PROJECT OPERATIONAL PLAN FOR THE

1999-2000 SEASON SOUTHEAST ALASKA HERRING STOCK ASSESSMENT

By

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INTRODUCTION

In 1971 the Alaska Department of Fish and Game (ADF&G) instituted a herring research program to evaluate herring stocks in Southeast Alaska. Visual estimates, hydroacoustic surveys, and spawn deposition surveys using scuba diving have been used for biomass assessment, particularly in areas judged to support significant herring populations. This Project Operational Plan (POP) describes the data required for assessing the abundance and condition of herring populations in Southeast Alaska, and the methods and rationale for collecting those data. Data generated during these stock assessment programs are used directly in the management of all commercial herring fisheries conducted in Southeast Alaska.

The data described in this POP are used as input into two different stock assessment models used to determine historic abundance and forecast future abundance of herring populations. These models include an age-structured analysis (ASA) model and a biomass accounting model (Figure 1).

Historically, biomass estimates and abundance forecasts of mature herring in Southeast Alaska were either developed from hydroacoustic surveys or, more recently, the product of estimates of egg density and area of spawn deposition (called "spawn deposition" method). Presently the ASA model is used for herring populations with longer (i.e. > 10 years) time-series of stock assessment data and the biomass accounting model is used for all other populations. The two methods are not mutually exclusive. Spawn deposition data, upon which the spawn deposition method is completely reliant, is also an important element of ASA and biomass accounting models. A primary difference between the three methods is the amount of data needed to conduct the respective analyses. Spawn deposition analysis uses only the most recent spawn deposition data and no specific age composition or weight data to yield an estimate of current and future biomass. A standard of 100,000,000 eggs per ton of herring was applied to the total egg estimate to compute spawning escapement. In contrast, the ASA uses a time series of age compositions and weights-at-age in conjunction with spawn deposition to estimate biomass. Biomass accounting is based on spawn deposition estimates adjusted for natural mortality, age-specific growth, and recruitment. Beginning in 1993, ASA, with auxiliary information, has been used to estimate the abundance of herring for four major southeastern herring fishery populations: Sitka, Seymour Canal, Revillagigedo Channel (Kah Shakes/Cat Island) and Craig/Klawock. These four major fishing areas or populations have a sufficiently long time series of data to permit the use of ASA for estimating historical and forecasting future biomass. Other areas, which may support significant herring fisheries but lack data time-series suitable for ASA, are candidates for biomass accounting. This approach began in 1996 and biomass accounting forecasts have been made for Tenakee Inlet, West Behm Canal, Ernest Sound, Ship Island, Hobart Bay/Port Houghton, and Hoonah Sound.

The principal outputs from all models are forecasts of mature herring biomass for the ensuing year. These forecasts are compared to stock-specific threshold biomass levels to determine whether a fishery will be allowed in a particular area. This biomass forecast is coupled with appropriate exploitation rates to determine the commercial fishing quota.

OBJECTIVES

The ASA model uses a least-squares procedure to yield estimates of historical abundance that are as consistent as possible with the objective estimates listed below. In the context of a least squares procedure, the objective estimates may be thought of as the "observed" data, and the ASA model estimates, derived to be as close to the "observed" data as possible, as the "expected" values.

All three forecasting models are currently deterministic models. That is, the error structure of parameter estimates used as input into the models are not expressly accounted for in the models, nor do the models provide variances for resulting parameter estimates, such as abundance of age-3 herring. If the models were stochastic, the desired precision of input parameter estimates (e.g. catch age compositions) might be dictated partly by the desired precision of output parameter estimates. Until the ASA model is sufficiently refined to account for variability in both input and output parameters, sampling design criteria related to sample sizes and variance estimation will be determined individually for each of the objective estimates listed below, and largely independent of the influence of the estimates on the ASA model. Sampling designs for each objective estimate will account for the usual tradeoffs between the costs of acquiring the data and the precision of resultant estimates.

A more detailed explanation of the ASA model and how the objective estimates are used in the model are provided by Carlile et al. (1995).

Objective 1 - Estimate total annual herring spawn deposition.

Estimates of spawn deposition (total numbers of herring eggs), in conjunction with information on fecundity, yield estimates of escapement or absolute abundance for use in both the biomass accounting and ASA models. We will use target-sampling intensities sufficient to achieve estimates of mean egg density so the lower bound of the one-sided 90% confidence interval is within 30% of the mean density. Egg density is sampled on transects by scuba divers. Estimated lengths of beach with herring spawn, the second critical component for abundance estimates, will be determined with aerial and skiff surveys.

Objective 2 - Estimate fecundity of herring in S.E. Alaska

As indicated under Objective 1, estimates of fecundity are used with spawn deposition estimates to determine absolute abundance of herring populations. In 1995, 1996, and 1998 revised fecundity-at-weight estimates were obtained for one or more of the four major herring spawning areas (Sitka, Craig, Revillagigedo Channel, and Seymour Canal). This procedure requires sufficient samples of female herring distributed optimally among ten 20-g weight classes to promote estimates of fecundity-at-weight at the extremes of the weight range that are within +/- 30% of the predicted fecundity, 90% of the time. No fecundity estimates will be made during the 2000 season.

Objective 3 - Estimate age composition of herring in commercial catches.

To estimate the historical abundance and forecast future abundance of herring, the ASA model uses catch and weight-at-age data to produce estimates of abundance, commercial gear selectivity, and natural mortality. These estimates yield model-estimated catch age compositions as close to field-estimated (i.e.

observed) catch age compositions, mature age compositions, and spawn depositions as possible. Based on multinomial sampling theory, sufficient samples will be obtained to promote estimates of catch age composition that are within ±5% of the true age composition, on an absolute basis, 90% of the time.

Objective 4 - Estimate age composition of mature herring populations.

As with catch age compositions, age compositions of mature herring populations based on cast net or trawl sampling of pre-spawning herring, serve as "observed" data for the ASA model. The model estimates age-3 abundance, maturity-at-age, natural mortality, and estimates of catch-at-age to yield model estimates of mature age composition as close to the "observed" estimates of age composition as possible. Target precision for estimates of mature age composition is the same as for catch age compositions.

Objective 5 - Estimate age-specific weights and lengths of mature herring.

Age specific weights are necessary to estimate the "observed" numbers of herring caught at age. Numbers of fish sampled to estimate mean weights-at-age are dictated by the precision guidelines advanced for determination of age compositions (Objective 4), since the same fish sampled for age composition estimates are used to estimate mean weights-at-age. Therefore the precision of weight estimates attainable will fluctuate.

METHODS

Dive Operations

An ADF&G research vessel (e.g. *R/V Sundance*) will be on site during spawn deposition surveys of each area and serve as the support vessel and base for all dive operations. The only exception anticipated is the possible use of skiffs for day trips near Ketchikan for the West Behm Canal stock. The *R/V Sundance* will accommodate all members of the dive team (usually 6 persons), in addition to vessel officers (usually 2 persons) for extended periods. Typically, the support vessel remains in a location central to dive activity during the survey.

Actual diving will be conducted from outboard powered skiffs. Three-person teams (2 divers, 1 skiff tender) will be assigned to a skiff. All dives will be done in pairs, with one team member remaining in the skiff to monitor surface traffic and provide support and assistance to the diving members of the team. Team members will rotate diving/tending responsibilities when appropriate. Equipment required for dive surveys, such as scuba gear and sampling/data collection equipment, is assembled on-board the support vessel to reduce unnecessary trips between support vessel and dive site. While conducting surveys, teams may be separated from the support vessel by as much as 5 nautical miles.

Spawn Deposition

Aerial Surveys

Beginning in mid-March, the historical start of herring spawning in some areas, daily fixed-wing aerial surveys will be conducted in locations where spawning is anticipated. Flights will be coordinated within each management area by the Area Management Biologist. Locations surveyed during 1999 are presented in Appendix C.

During aerial surveys ADF&G personnel indicate on a chart the shoreline where active spawning occurs. Additionally, indications of herring schools, presence of recent or old milt, presence and numbers of seabirds and marine mammals, and other information relevant to herring spawning, is noted. On occasion, the aircraft will land to collect samples for estimates of age, weight, and length, using a cast net. Aerial surveys will continue until active spawning is no longer observed in an area.

Upon completion of an aerial survey, notes will be transcribed and presented, with charts indicating spawn activity, to the herring research biologist. Data will be used to calculate the total nautical miles of shoreline receiving spawn and will help to determine position of transects used for spawn deposition dive surveys.

Sampling Design

A two-stage sampling design, similar to that of Schweigert et al. (1985), is used to estimate the density of herring eggs at selected spawning locations in Southeast Alaska. The field sampling procedure entails two-person scuba teams swimming along transects (first stage of sampling) and recording visual estimates of the number of eggs within a square, 0.10 m^2 sampling frame (second stage of sampling) placed on the bottom at fixed distances along the transects.

The specific approach is as follows: diver 1 holds a 0.10 m^2 sampling quadrat (frame) with an attached compass. Diver 2 holds an underwater writing slate with an attached diving computer for depth and dive time at depth, along with an attached data sheet for recording distance covered, depth, bottom type, percent vegetative cover, most prevalent vegetation type, number of herring eggs observed, and other comments. Diver 1 sets a compass course perpendicular from the beach. Starting at a point approximately 2.5 m inside any intertidal spawn, or at the water line if not intertidal spawn is observed, divers swim along the pre-determined course, and place the sampling frame systematically (to avoid biased placement of the frame) every five meters. Distance is measured using a 5-meter line tied to the sampling frame. Divers stop every five meters. If eggs are not present the estimate is entered as “0”. When eggs are present, diver 1 visually estimates the number of eggs observed within the entire water column defined by the frame. Often the frame cannot be placed on the bottom without displacing eggs and vegetation and must be held in mid-water column. This may require estimating numbers of eggs both above and below the frame as they occur on substrate. Diver 1, using hand signals, indicates his estimate to diver 2 to record. Diver 2 also records depth, distance covered, bottom type, percent vegetative cover, vegetative type, and any additional observations. Vegetative type will be coded using a key that groups various algae and marine and intertidal plants species into categories (Appendix A). Similarly, bottom type will be coded according to Appendix B. Since frames are spaced equidistantly along transects, the number of frames is also used to compute individual transect length.

Starting points for transects are located randomly along the shore within areas where aerial or skiff surveys indicated probable spawn deposition. Transects are oriented perpendicular to the shoreline. Dives are limited generally to 15 meters MLLW because deeper dives severely limit total bottom times for scuba divers and pose safety risks when done repetitively over several days. In addition, little if any herring egg deposition normally occurs deeper than 15 m.

Upon completion of a survey dive, all data will be entered into a database on-board the supporting research vessel or at the earliest convenience. When possible, the collector of the data will complete data entry.

Diver Calibration

Since visual estimates, rather than complete counts of eggs within the sampling frames are recorded, measurement error occurs. To minimize the influence of this measurement error on final estimates of total egg deposition, diver-substrate-specific correction coefficients (ch) are used to adjust estimates of egg density. Correction coefficients are estimated by double sampling (Jessen 1978) a sample of frames separate from those estimates obtained along regular spawn deposition transects. This involves visually estimating the number of eggs within a sampling frame and then collecting all of the eggs within the frame for later enumeration in the laboratory. To collect the eggs, divers will carefully collect all of the kelp containing eggs located within the frame and place the samples in collection bags. Eggs that are attached to rocks and other uncollectable substrates often remain within the frame. To account for these residual eggs, divers will estimate and record the number of eggs remaining within the frame. The estimated number remaining will be added to the laboratory count. In previous years, samples were preserved in Gilson's solution (Nielsen and Johnson 1983). In 2000 all samples will be preserved in a 100% salt brine solution until laboratory analysis. A detailed description of the processing and counting of collected eggs in the laboratory is provided in Blankenbeckler (1987).

Given the visual estimates and actual counts of eggs, the diver-specific correction factors are estimated as:

$$c_h = \frac{k_h}{v_h}, \tag{1}$$

where:

c_h = estimated correction factor for diver *h*,
v_h = mean visual estimate of egg numbers for diver *h*,
k_h = mean laboratory count of egg numbers for diver *h*.

Estimates of Total Egg Deposition

For each spawning area, *i*, total egg deposition is estimated as:

$$t_i = a_i \bar{d}_i, \tag{2}$$

where:

t_i = estimated total deposition of eggs for spawning area *i*,
a_i = estimated total area (m^2) on which eggs have been deposited at spawning area *i*,
$\bar{d}_i$ = estimated mean density of eggs (eggs/m^2) at spawning area *i*.

The total area on which eggs have been deposited is estimated as:

$$a_i = l_i w_i , \tag{3}$$

where:

l_i = total meters of shoreline receiving spawn (determined from aerial and skiff surveys) at a spawning area *i*.
w_i = mean length of transects conducted at a spawning area *i*.

The mean density of eggs per 0.1 m^2 quadrat is estimated as:

$$\overline{d_i} = \frac{\sum v_h c_h}{\sum m_h}, \tag{4}$$

where:

m_h = number of quadrat visually estimated by diver *h*.

Sample Size

The statistical objective of spawn deposition sampling is to estimate herring egg densities (per quadrat) so the lower bound of the one-sided 90% confidence interval is within 30% of the mean density. This will also achieve the objective of estimating the total spawn deposition at a particular location with the specified precision. A one-sided confidence interval is used because we are concerned more with avoiding overestimating, rather than avoiding underestimating the densities of spawn deposition. Since spawn deposition surveys are conducted as two-stage sampling, target precision can be achieved by changing the number of transects per nautical mile of shore and/or by changing the number of quadrats within transects per nautical mile of shore. Sampling optimization, which accounts for both the costs and variances specific to each stage of sampling, could be used to obtain optimum estimates of egg density given constraints on precision and cost. This approach would necessitate some flexibility in varying both the transect density (i.e. number of transects per nautical mile of shore) and quadrat density (i.e. number of quadrats per meters of transect) at the various spawning areas. Since a length of line is now used to measure inter-quadrat distances, it would be practical to optimize the spawn deposition sampling by varying not only the number of transects per nautical mile, but also the number of quadrats per transect specific to each spawning area. During the 2000 season, methods of optimizing spawning surveys inseason may be explored. However, to simplify the sampling and reduce chances of error, a standard quadrat spacing of one quadrat every 5 m of transect will be maintained. This standardization simplifies estimation of desired sample sizes, since the target precision is achieved by changing only the number of transects.

The desirable number of transects to achieve a specified precision is estimated as:

$$n = \frac{\left(S_b^2 - \frac{S_2^2}{\overline{M}} + \frac{S_2^2}{\overline{m}} \right)}{\left(\frac{x\overline{d}}{t_\alpha} \right)^2 + \frac{S_b^2}{N}}, \qquad (5)$$

where:

n = number of transects needed to achieve the specified precision,
S_b^2 = estimated variance in egg density among transects,
S_2^2 = estimated variance in egg density among quadrats within transects,
$\overline{M}$ = estimated mean width of spawn,
$\overline{m}$ = estimated mean number of 0.1 m quadrats per transect,
x = specified precision, expressed as a proportion (i.e. 0.3 = 30%),
$\overline{d}$ = overall estimated mean egg density,
t_a = critical t value for a one-sided, 90% confidence interval,
N = estimated total number of transects possible within the spawning area.

These preliminary estimates may be obtained from the prior year's spawn deposition surveys, or may be obtained from preliminary sampling from the current years' sampling and updated as the current years' survey proceeds (Table 1). The latter approach is preferred if possible. From a practical standpoint, the number of transects conducted in an area will be set as a minimum of 15 and not to exceed 40.

Transect Location

Once the desired number of transects per nautical mile of spawn is determined, transect location is decided through a process of measuring the distance of shoreline that received spawn and then randomly selecting locations. The measurement process uses either: 1) a map depicting spawn areas and a divider, or 2) GIS software (preferred method). Measurements of shoreline are always taken from south to north and counter-clockwise around islands.

Shoreline measurement and transect placement can be subjective and depend on the location of spawn deposition relative to the shoreline, bottom contour and depth, and map resolution. Fine measurement of a convoluted shoreline may substantially increase distance but may not be appropriate for instances when spawn deposition does not closely follow the shoreline. In such situations, less resolution is used for measurements and transects are placed perpendicular to a "theoretical" shoreline so they intersect the spawn in a meaningful way. Conversely, spawn may closely follow a convoluted shoreline, requiring finer resolution of measurements, and transects are placed perpendicular to the actual shoreline, contingent upon physical features, such as depth, bottom slope, and distance to the opposite shore. For example, a steep sloped shore with a narrow band of spawn habitat (e.g. Sitka) requires much finer shoreline mapping as opposed to an area with broad shallow waters (e.g. Cat Island) interspersed with rocks and reefs at some distance from shore.

The product of the total measured shoreline and the estimated optimal number of transects per nautical mile (Table 1) determines the total number of transects to be surveyed in an area. Total measured

shoreline that received spawn is divided into tenths of a nautical mile and each of these segments becomes a candidate for transects location. The number and location of transects to be surveyed are then selected from these segments using a random number generator.

Fecundity

Sampling Design

No fecundity sampling will be conducted during the 2000 season. In future years it is anticipated that sampling will be conducted so regression estimates of fecundity, as a function of one or more of the attributes weight, length, and age can be obtained. If fecundity were strictly a linear function of size and/or age, the optimum sampling strategy would be to sample only from among the smallest and largest herring categories. Alternatively, if non-linearity in the relationship is known or suspected, sampling from intermediate sizes is also needed to define the form of the relationship. Analyses of historical fecundity-at-age data from Southeast Alaska herring suggest at least a possibility of slight non-linearity in the relationship. Therefore, sampling will be conducted from the full spectrum of size classes of mature herring.

Sampling was conducted in Sitka for 1995, followed by Revillagigedo Channel (Cat Island) and Craig in 1996 and 1997, respectively, and Seymour Canal and Sitka in 1998.

Sample Size

The following criteria will be used in formulating fecundity sampling protocols for areas in subsequent years. Weights of mature herring may range from 40g for an age-3 fish to over 200g for an age-10 fish. Given this likely range of weights, and the need to sample to define a possible nonlinear relationship, sampling will be conducted equally from this full range of weights. Sampling will be conducted by selecting from commercial seine net samples a minimum of 10 reproductively mature female herring from each of the following 20g weight categories: <80, 80-99, 100-119, 120-139, 140-159, 160-179, 180-199, 200-220, and >220. This will yield a minimum of 90 herring to be analyzed to define a fecundity relationship. This total sample size is dictated largely by limitations on the number of fish that can reasonably be processed in the lab given the available personnel.

Catch Age Composition

Sampling Design

Samples will be collected from at least four different vessels participating in each of the commercial herring fisheries. Apportioning samples among vessels and positions within sets is intended to promote more representative estimates of age compositions. Sampling from tenders at the processing plants may be required for the winter bait fishery, but is not preferable due to scale loss. Samples will be stored in 5-gallon buckets and shipped to the Juneau tag lab for processing at the earliest convenience. Information

with each sample will include: date of set, location of set, name of vessel making the set, name of person collecting sample, commercial gear used in making the set and the approximate size of the set if the gear type is purse seine. Samples will be collected from all commercial fisheries conducted during the year.

Generally, the assistant commercial fishery management biologist for each area is responsible for sampling at each fishery.

Sample Size

Based on multinomial sampling theory (Thompson, 1987), a sample size of 400 fish with individual fish apportioned among six age categories (i.e. Ages 3-8+), is sufficient to assure age composition estimates that deviate no more than 5% (absolute basis) from the true value, 90% of the time. To achieve this sample size and promote adequate sampling from a cross section of the commercial catch, approximately 100 herring will be taken from each of at least four different vessels participating in the commercial fishery.

Mature Age Composition

Sampling Design

Cast net and/or seine samples will be collected annually from areas that have historically been sampled and/or which have significant pre-spawning and spawning activity.

Sample Size

A minimum of 100 fish will be taken from each of at least four different times and/or sites within the general spawning locale prior to or during the onset of the major spawning event. Sampling gillnet sac roe fishery areas should be completed prior to the onset of any commercial fishery in the area. Sampling prior to the fishery is necessary to minimize possible bias in the age compositions and size estimates caused by selectivity of the commercial gillnet gear.

Age-Specific Weight And Length

Sampling Design

The sampling design for estimating age-specific weight and length is dictated by the design used to estimate mature and catch age compositions, since the same fish are used for estimating age, weight, and length.

Sample Size

The precision of the estimates of mean weights and lengths-at-age will vary depending upon age composition of populations and therefore the numbers of herring within the various age classes among the total of 400 fish sampled. In addition, precision will vary depending upon inherent variability in weights among fish within the various age classes.

Special Projects

Stock Identification

Interaction among Pacific herring populations is not well understood and management for sustainable herring fisheries can be compromised when stocks are considered genetically isolated (partially or wholly) when if in fact they are part of a larger population or vice versa. Several methods have been developed to identify stocks of fish. Among these are techniques that analyze genetic materials directly by comparing DNA among populations and indirectly by comparing DNA determined or influenced attributes.

We will be contributing to a study conducted by the Canadian Department of Fisheries and Oceans designed to identify British Columbia and Alaska herring stocks. The study will attempt to identify herring stocks by using DNA techniques. This study will be done in conjunction with a coded wire tag study in Canada to determine mixing and migration of the same herring stocks. Participation by ADF&G will be limited to sampling and delivering herring according to the methods outlined in Appendix E. Samples will be collected from Seymour Canal, Sitka Sound, and Kah Shakes/Cat Island populations.

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SCHEDULES

Herring stock assessment data collection schedule, 2000

Dates (approx.) of spawn deposition surveys: April 1 – May 22

Scheduled locations

Surveys are anticipated to be conducted in the following locations in this sequence:

Sitka Sound
Kah Shakes / Cat Island
Craig
West Behm Canal
Hobart Bay / Port Houghton
Hoonah Sound
Tenakee Inlet
Seymour Canal

Locations to be surveyed biennially

Ernest Sound (if there is significant spawn during 2000)

Participating divers (depending on availability)

Robert Larson
Kyle Hebert
Marc Pritchett
Scott Walker
Phil Doherty
William Bergmann
Tim Koeneman
Bill Davidson
Dave Gordon
Brian Lynch
Troy Thynes

REPORTS

The following are reports to which this project will contribute:

Date	Author (s)	Report
October 2000	R. Larson, K. Hebert	Southeast Alaska/Yakutat Annual Herring Research Report, 1999 2000 Season
February 2000	ADF&G staff	Southeast Alaska Sac Roe Herring Fishery, 2000 Management Plan
March 2000	ADF&G staff	Hoonah Sound Herring Spawn on Kelp Pound Fishery, 2000 Management Plan
March 2000	ADF&G staff	Craig/Klawock Herring Spawn on Kelp Pound Fishery, 2000 Management Plan

DATA ENTRY / DATABASE AND SOFTWARE REQUIREMENTS

All spawn deposition data will be entered into an Access database by a designated dive team member within the same day of data collection (if possible) to maximize recall of dives. Ideally, the collectors of the data will enter data. Upon completion of the cruise, data files will be imported into a master database.

OTHER NECESSARY RESOURCES

The *R/V Sundance*, based in Petersburg, will be used as the support research vessel and base dive platform for herring spawn deposition cruises. This is a 72-foot vessel, capable of accommodating 6 divers in addition to vessel officers. It is equipped with compressors for on-board filling of scuba tanks with air and NITROX.

One or two aluminum skiffs that have been enhanced for diving purposes will accompany the support research vessel. Skiffs will be towed by the support vessel to the project site.

Table 1. Numbers of transects needed to estimate the lower bound of a 1-sided confidence interval that is within the specified % of the total spawing biomass escapement 90% of the time.[a]

	No. transects per nautical mile to achieve lower bound of 90% CI within :						
		30% of the mean				No. transects needed in '00 assuming the same length spawn deposition as '97	
Area	25% of the mean[b]	based on ***old*** 1994 analysis[c]	based on ***new*** 1997 analysis	35% of the mean	1997 miles of spawn	30% of mean	35% of mean
Sitka	0.8	0.2	0.6	0.4	37	**22**	16
Kah Shakes/Cat I.	2.5	1.0	1.8	1.3	14.7	**26**	20
Seymour Canal	3.5	2.8	2.4	1.8	8.2	**21**	15
Craig	4.5	0.8	3.1	2.3	13.2	**42**	31
Hobart/Houghton	4.9	4.5	3.4	2.5	5.3	**19**	14
Ernest Sound	7.2	1.9	5.0	3.7			-
Hoonah Sound	2.3	2.9	1.0	0.7	14.5	**15**	11
Tenakee Inlet	1.8	5.1[d]	1.3	0.9	16.5	**22**	15
W. Behm Canal	0.6	-	0.4	0.3	24	**11**	8

[a] This is precision needed to achieve estimates of total spawning escapement so that the lower bound of a 90% confidence interval is within 30% of the total estimates based on 1997 data, except Vixen is 1996.

[b] Unless otherwise noted, results based on analyses of 1997 data.

[c] Old analysis was based on achieving a specified precision for the egg density estmate on a $0.1m^2$ quadrat.

[d] Based on 1993 data.

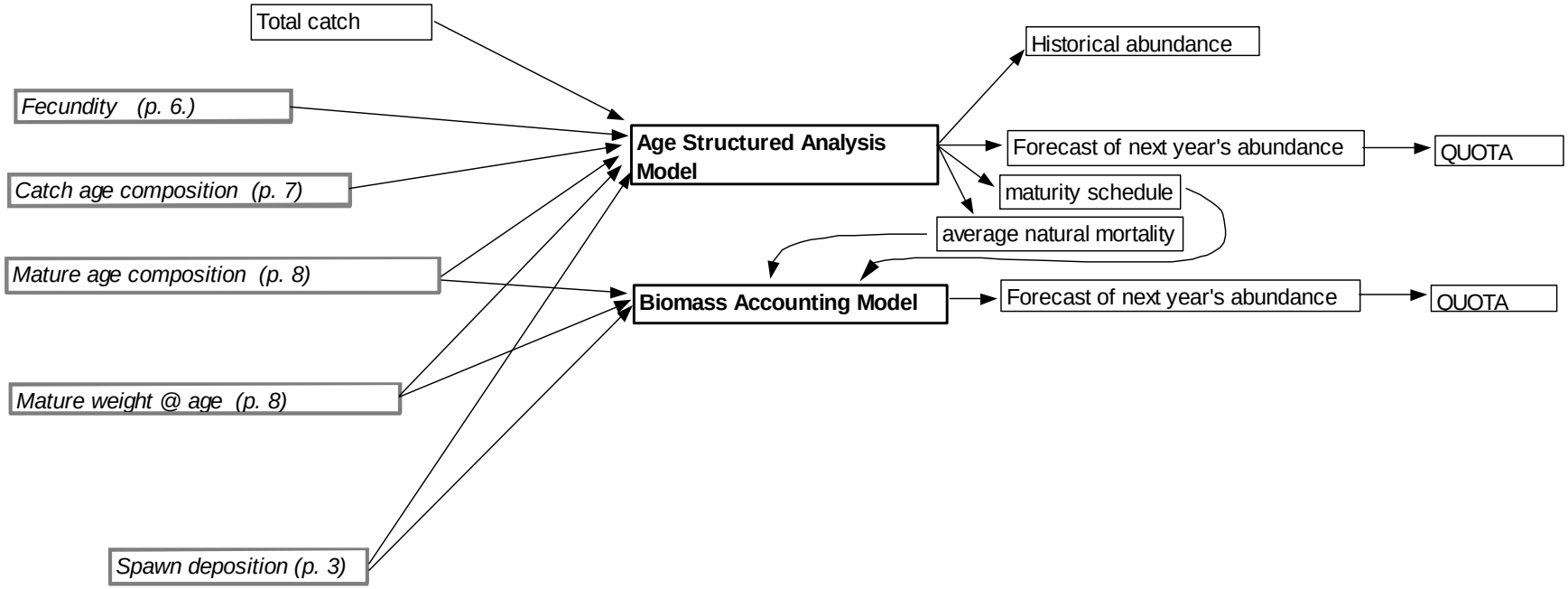


Figure 1. Schematic of relationships between major elements of Southeast Alaska herring stock assessment program. Page numbers in parentheses indicate where the element is described in the project operational plan.

APPENDIX

Appendix A. Key to vegetative substrate types used for herring spawn deposition survey.

CODE	EXPANDED CODE	SPECIES INCLUDED	LATIN NAMES
AGM	Agarum	Sieve kelp	*Agarum clathratum*
ALA	Alaria	Ribbon kelps	*Alaria marginata, A. nana, A. fistulosa*
ELG	Eel grass	Eel grass, surfgrasses	*Zostera marina, Phyllospadix serrulatus, P. scouleri*
FIL	Filamentous red algae	Sea brush, poly, black tassel	*Polysiphonia pacifica, P. hendryi, Pterosiphonia bipinnata*
FIR	Fir kelp	Black pine, Oregon pine (red algae)	*Neorhodomela larix, N.oregona*
FUC	Fucus	Rockweed or popweed	*Fucus gardneri*
HIR	Hair kelp	Witch's hair, stringy acid kelp	*Desmarestia aculeata, D. viridis*
LAM	Laminaria	split kelp, sugar kelp, suction-cup kelp	*Laminaria bongardiana, L. saccharina, L. yezoensis (when isolated and identifiable)*
LBK	Large Brown Kelps	Five-ribbed kelp, three-ribbed kelp, split kelp, sugar kelp, sea spatula, sieve kelp, ribbon kelp	*Costaria costata, Cymathere triplicata, Laminaria spp., Pleurophycus gardneri, Agarum, Alaria spp.*
MAC	Macrocystis	macrocystis	*Macrocystis integrifolia*
NER	Nereocystis	Bull kelp	*Nereocystis leutkeana*
RED	Red algae	All red leafy algae (red ribbons, red blades, red sea cabbage, Turkish washcloth)	*Palmaria mollis, P. hecatensis, P. callophylloides, Dilsea californica, Neodilsea borealis, Mastocarpus papillatus, Turnerella mertensiana*
ULV	Ulva	Sea lettuce	*Ulva fenestrata, Ulvaria obscura*
COR	Coralline algae	Coral seaweeds (red algae)	*Bossiella, Corallina, Serraticardia*

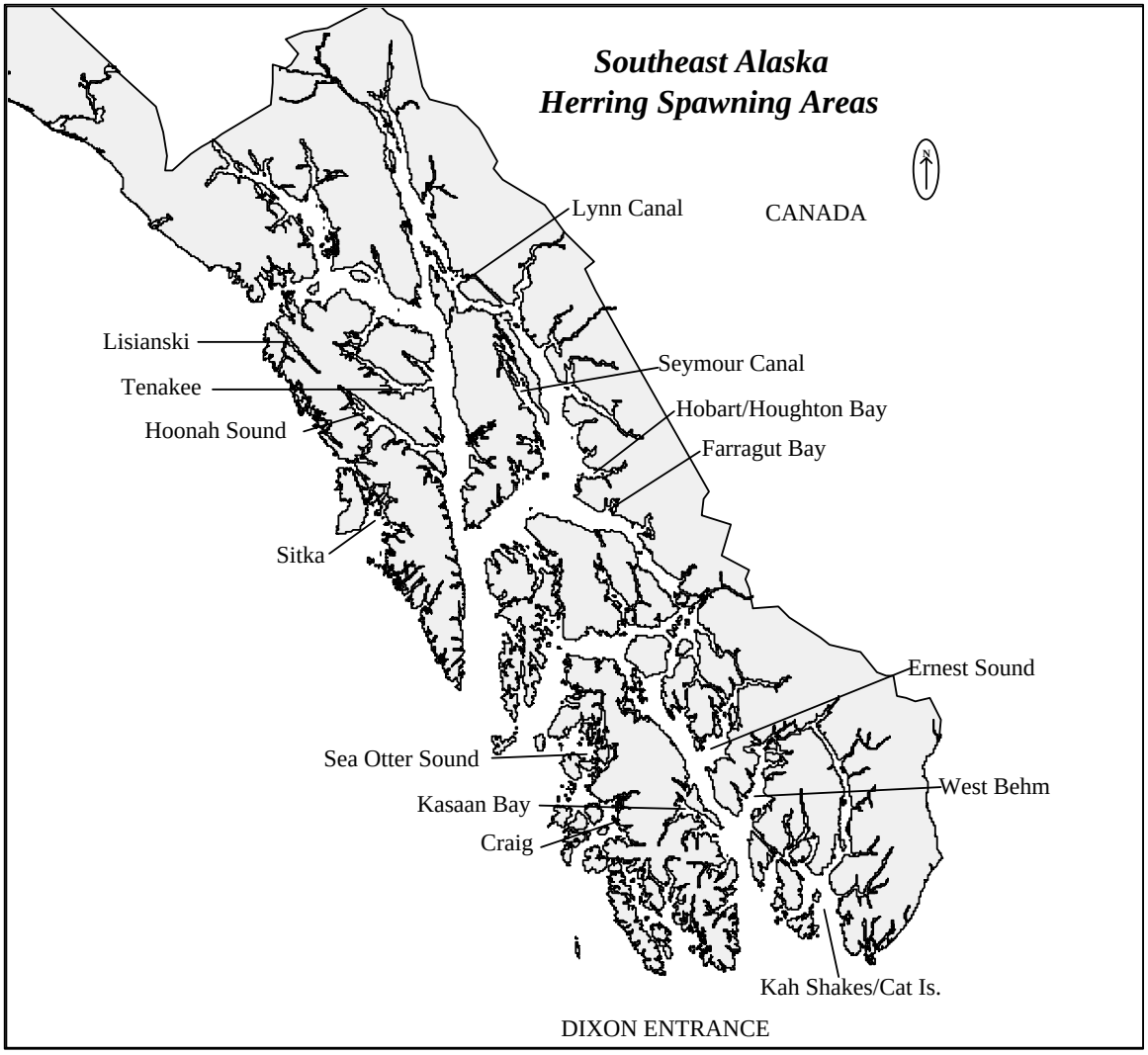
Appendix B. Key to bottom types used for herring spawn deposition survey.

CODE	EXPANDED CODE	DEFINITION
RCK	Bedrock	Various rocky substrates > 1 meter in diameter
BLD	Boulder	Substrate between 25 cm and 1 meter
CBL	Cobble	Substrate between 6 cm and 25 cm
GVL	Gravel	Substrate between 0.4 cm and 6 cm
SND	Sand	Clearly separate grains of < 0.4 cm
MUD	Mud	Soft, paste-like material
SIL	Silt	Fine organic dusting (very rarely used)
BAR	Barnacle	Area primarily covered with barnacles
SHL	Shell	Area primarily covered with whole or crushed shells
MUS	Mussels	Area primarily covered with mussels
WDY	Woody debris	Any submerged bark, logs, branches or root systems

Appendix C. Locations and dates of spawn deposition surveys in 1997, 1998, and 1999.

LOCATION	1997 DATES SURVEYED	1998 DATES SURVEYED	1999 DATES SURVEYED
Sitka Sound	April 7-9	April 1-3	April 7-9
Kah Shakes / Cat Island	April 16-17	April 9-11	April 14-15
Craig / Klawock	April 22-23	April 12-14	April 10, 20
West Behm Canal	April 29 – May 1	April 20-22	April 15-17
Hobart Bay / Port Houghton	May 9	April 29-30	May 4-5
Hoonah Sound	May 6-8	May 4-5	May 9
Tenakee Inlet	May 10-11	May 6-7	May 7-8
Seymour Canal	May 12-13	May 2, 8-9	May 11-12

Appendix D. Southeast Alaska traditional herring spawning locations.



Appendix E. Sampling procedure for herring DNA stock identification study.

Herring DNA Sampling Procedure:

1) Samples must be taken near spawning grounds. We assume that fish with roe maturity of 8% or more are close to the area they will spawn in. If you make a set on 8% fish in one of the areas listed above please collect a DNA sample as described below.

2) Collect one sample = 200 fish (2 boxes of vials) from one location (e.g. Lambert Channel). Use the plastic tray for sampling on deck and then return vials to cardboard boxes.

3) If males are ripe and running spread fish out on the sampling tray as soon as possible to minimize contamination of samples from milt covering other fish.

4) Collect a sample of tissue using either the corer to take one sample of muscle tissue from behind the head (easiest location) or take one punch from the cheek or gill cover; if males are running please use the corers to get better tissue samples. Note: don't take too much tissue because the ethanol won't preserve it (a piece of muscle less than ½ the size of your baby fingernail is more than enough).

5) Use the wooden plunger (Qtip) to push the tissue from the corer into the vial, fill the vial with enough 70% ethanol from the squirt bottle to cover the tissue sample, screw cap onto the vial. Only tissue from one fish in each vial. If for some reason there is a shortage in supply of 70% ethanol, you can substitute with 90% to 99% rubbing alcohol (isopropynol).

6) Rinse the corer or punch in water after each fish to minimize contamination of the sample. Discard each fish after sampling; do not sample same fish twice.

7) Label each box of vials with date, set number, sample number, statistical area, location name, vessel name. Note: If boxes get wet and start to fall apart put all the vials in a plastic bag with labels inside and outside and seal bag.

8) After sampling is complete and boxes are labeled put elastic band around the box or tape up each box of 100 sample vials.

The box of vials can be stored in your briefcase and returned at the end of the charter, there is no need to refrigerate them. Rinse the tissue corer or paper punch in fresh water and dry after the sample is completed to minimize rust.

Sampling requires:

PER BOAT OR COLLECTOR	PER DNA SAMPLE OF 200
▪ 1 plastic tray ▪ 1 alcohol squirt bottle ▪ 1 metal hole puncher	▪ vials and lids (1.5 ml volumes) ▪ 95% ethanol (approximately 500 ml for each DNA sample of 200) ▪ tissue core borers ▪ poking sticks to plunge tissue out of core borers

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